Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 02, February-2016

An Experimental Study on Geosynthetics as Base Isolators

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Abstract **- Base isolation is a technique used for mitigating seismic response of structures, which has now been around for a while, but not much popular due to its higher cost. However, the technique has been applied in state of the art buildings. Base isolation is achieved by deliberately increasing the time period of the structure. The present study is aimed at assessing the validity of geotextile as base isolator and its application as an isolator in mitigating the response of an RC Frame building model. Geosynthetic isolator is a friction isolator. The one-fourth scaled 2-storey three dimensional RC frame model is assessed under various earthquake simulated conditions using shake table. The results show that the geosynthetics can be used effectively as base isolator. The level of peak floor acceleration in the fixed base condition is about 1.3 to 1.9 time of the similar observed acceleration in isolated conditions, while the level of acceleration at the base level is about 0.52 to 0.77 time of the acceleration at the table level in isolated conditions.**

Keywords: Friction Isolator; Geosynthetic; Shake Table; Three Dimensional RC Frame Model.

1. INTRODUCTION

In recent years base isolation has becomepopular structural design technique for buildings and bridges in highly seismic areas. Many types of structures have been built using this approach, and many others are in the design phase or under construction. Most of the completed buildings and those under construction use rubber isolation bearings in some way in the isolation system. But the techniques are quite expensive for lower budgets project and if traditional base isolators are to be equipped on the small projects then, sometimes it could over run the cost of the overall project. Therefore, it provides a scope of research for cheaper base isolators for small scale projects.

In this paper the use of geosynthetics as a base isolators has been tried to be implemented on the scaled model of RC Frame structure to see its effectiveness. Here, the sliding friction isolator was used, with one geosynthetics layer attached to the base of the first storey column and other to the plinth level of the substructure. In the frictional base isolators the base filter out earthquake force via the discontinuous sliding interface between which the force transmitted to the superstructure are limited by the maximum frictional forces regardless of earthquake intensity.

2. EXPERIMENTAL PROGRAM

The shake-table experiments were carried out with a one-fourth scaled RC Frame building model with and without base isolation. The materials used in the model are M20 concrete, Fe415 and Fe250 rebar. The structure is isolated from the foundation using Non-Woven polypropylene geotextile GSM 180 as isolators. The building model has been subjected to harmonic excitation using geotextile using shake table. A series of dynamic tests have been conducted under different frequency inputs.

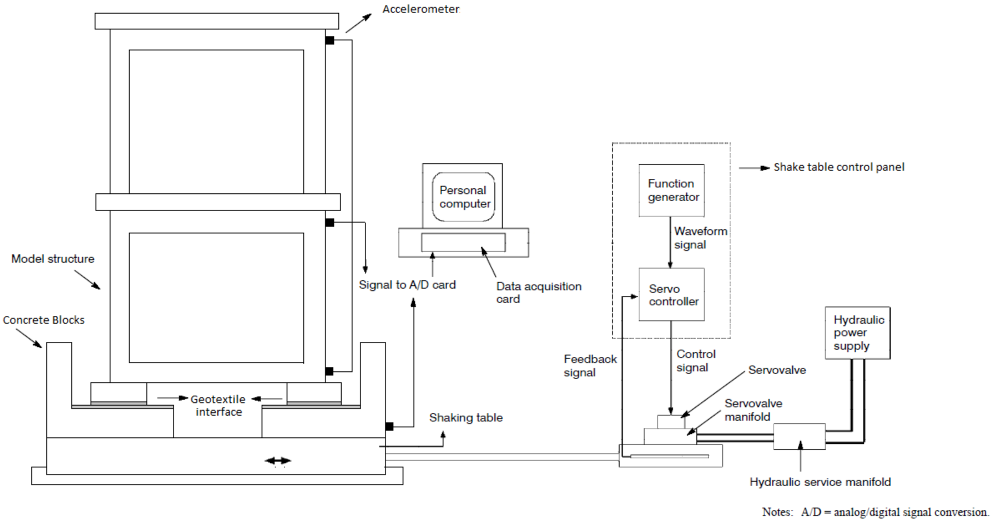

Fig. 1. Schematic Diagram of the Shake Table Test setup.

International Journal of Engineering Research & Technology (IJERT)
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The model structure was analyzed using shake table of 1m x 1m steel sliding platform driven by electric motor. The sliding platform slides on low friction channel bearings which are mounted on two ground mounted shafts. The operating frequencies of the shake table ranges from 0 Hz to 6 Hz. The maximum displacement of the table is ± 50 mm (manually adjustable). The maximum payload is 3000 kg. The table is capable of producing simple harmonic motion. The excitation frequency of the shaker can be controlled by means of a control panel.

Multi-function data acquisition systems are used to obtain measurements of physical quantities using sensors, transducers and 8 channel A/D card. Dynamic accelerometers are used to measure the acceleration of the structure.

The three dimensional model structure was analyzed using a commercial finite element program (DEWESOFT). The isolation system consisted of for friction sliding surfaces, which were placed under the base of the model at the distance of 0.5 m.

The foundation model blocks were casted in order to fix with the shake table through bolts. Shake table has 16.5 cm c/c spacing. As in the flat surface friction sliding system the building use to displace from its position when excited therefore vertical boundaries are provided.

The three dimensional model was tested under fixed base condition and then under base isolation condition of dry state and wet state.

3. TESTS AND RESULTS

The test program was tested with 10 different sinusoidal harmonic motions. The dynamic tests were performed at varying frequencies for fix base, dry and wet state of geotextile interface. In the test program the isolation condition, peak table acceleration, peak base acceleration, peak floor acceleration, interstorey drift and permanent displacement at the end of vibration response are computed.

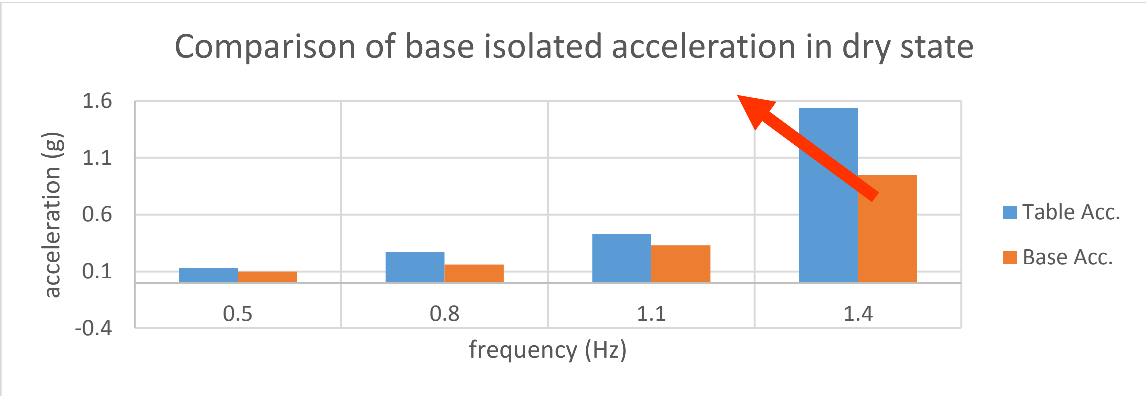

Fig. 5. Bar graph representing comparison between table acceleration and base acceleration in dry state

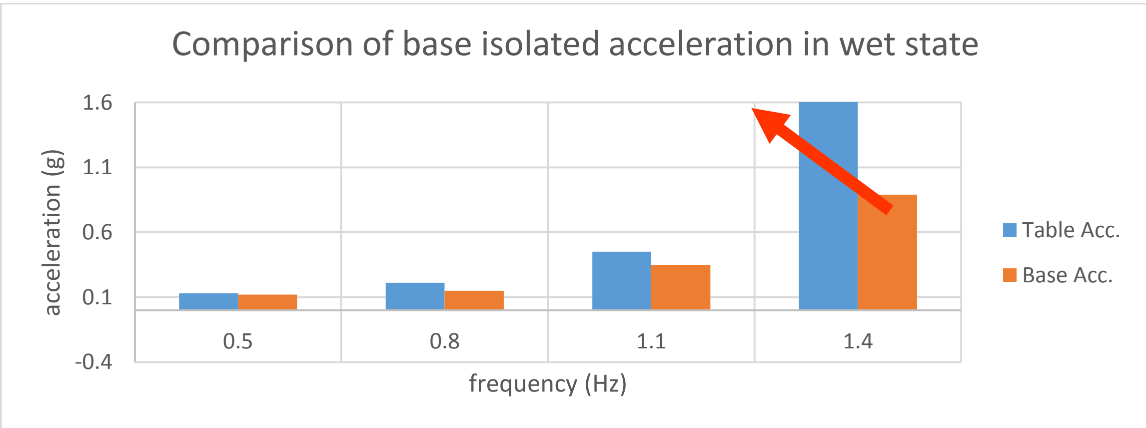

Fig. 6. Bar graph representing comparison between table acceleration and base acceleration in wet state

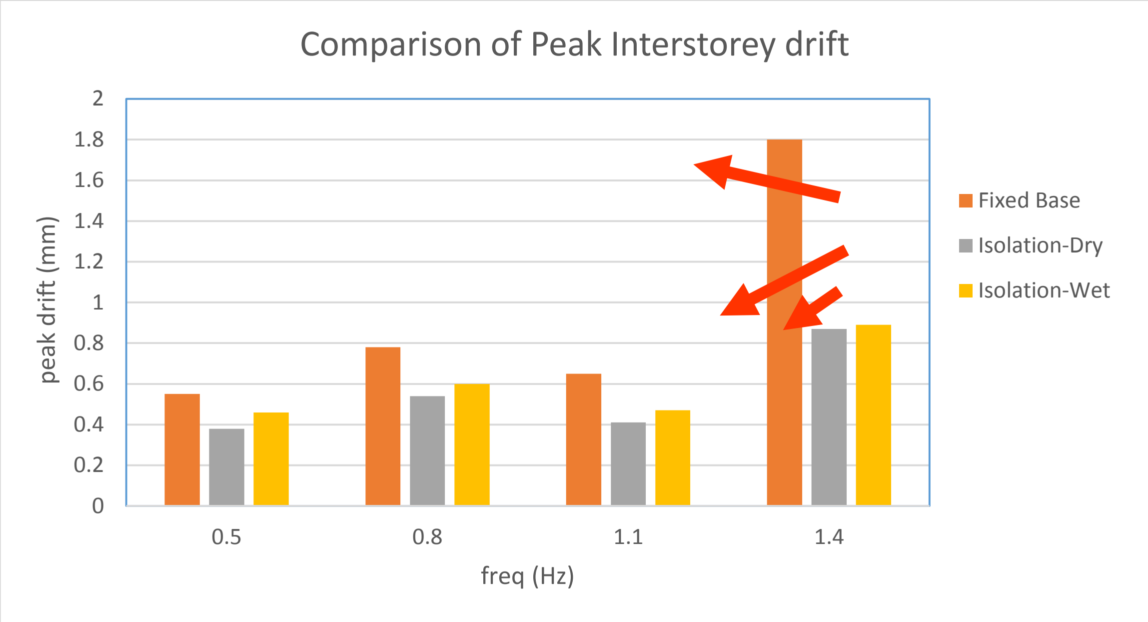

Fig. 7. Bar graph representing comparison Interstorey drift under various conditions.

Table 1. Summary of Experimental Results

Excitation (form) (Hz)	Isolation condition	Peak Table acc. (g)	Peak Base acc. (g)	Peak Floor Acc. (g)	Peak Base Displacement (mm)	Peak Interstorey drift (mm)	Permanent displacement (mm)
Sin 0.5 Hz	Fixed Base	0.13	-	0.18	-	0.55	-
Sin 0.6 Hz	Fixed Base	0.15	-	0.21	-	0.46	-
Sin 0.7 Hz	Fixed Base	0.18	-	0.31	-	0.32	-
Sin 0.8 Hz	Fixed Base	0.21	-	0.37	-	0.78	-
Sin 0.9 Hz	Fixed Base	0.28	-	0.42	-	0.63	-
Sin 1 Hz	Fixed Base	0.42	-	0.56	-	0.7	-
Sin 1.1 Hz	Fixed Base	0.47	-	0.61	-	0.65	-
Sin 1.2 Hz	Fixed Base	0.53	-	0.69	-	0.44	-
Sin 1.3 Hz	Fixed Base	1.21	-	1.7	-	1.42	-
Sin 1.4 Hz	Fix Base	1.63	-	1.91	-	1.8	-
Sin 0.5 Hz	FI- D	0.13	0.1	0.14	1.52	0.38	0.2
Sin 0.6 Hz	FI- D	0.17	0.165	0.16	1.57	0.35	0.37
Sin 0.7 Hz	FI- D	0.18	0.18	0.22	1.59	0.23	0.42
Sin 0.8 Hz	FI- D	0.27	0.16	0.24	2.8	0.54	0.53
Sin 0.9 Hz	FI- D	0.31	0.18	0.28	3.95	0.28	0.63
Sin 1 Hz	FI- D	0.41	0.22	0.31	4.34	0.56	0.74
Sin 1.1 Hz	FI- D	0.45	0.35	0.37	5.55	0.41	0.91
Sin 1.2 Hz	FI- D	0.49	0.37	0.43	6.98	0.65	0.98
Sin 1.3 Hz	FI- D	1.40	0.78	0.89	6.16	0.82	1.09
Sin 1.4 Hz	FI- D	1.54	0.95	0.98	7.54	0.87	1.16
Sin 0.5 Hz	FI- W	0.13	0.12	0.15	1.56	0.46	0.2
Sin 0.6 Hz	FI- W	0.14	0.16	0.18	1.61	0.33	0.38
Sin 0.7 Hz	FI- W	0.19	0.18	0.25	1.65	0.28	0.44
Sin 0.8 Hz	FI- W	0.21	0.15	0.28	2.98	0.6	0.56
Sin 0.9 Hz	FI- W	0.29	0.19	0.3	4.11	1.06	0.69
Sin 1 Hz	FI- W	0.38	0.25	0.34	4.86	0.57	0.82
Sin 1.1 Hz	FI- W	0.45	0.35	0.39	5.83	0.47	0.94
Sin 1.2 Hz	FI- W	0.51	0.39	0.47	7.34	0.15	1.02
Sin 1.3 Hz	FI- W	0.99	0.8	0.91	7.42	0.88	1.21
Sin 1.4 Hz	FI- W	1.71	0.89	1.03	7.61	0.89	1.34

Note: FI-D Friction Isolation Dry state
FI-W Friction Isolation Wet state

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It should be noted that the peak table acceleration in Table 1 for the same earthquake and level of input varies in the three conditions. This is because table-driven signals were not corrected to precisely reproduce the desired motions.

The results presented in this paper focus primarily on the results, using geotextile interface under dry and wet state. The first important observations to be made for the results of Table 1 is the effectiveness of the friction isolator in reducing the peak floor accelerations using the geotextile interface. For fixed base the peak floor accelerations for 0.8 Hz is almost equal to the 1.1 Hz under isolated dry condition. Thus the same amount of acceleration was observed for higher input responses. The level of acceleration in the fixed base condition is about 1.3 to 1.9 time of the similar observed acceleration in isolated conditions.

On comparing the results from the Table 1 it is observed that the peak table acceleration is larger than the peak base acceleration (illustrated in the Fig. 5 and Fig. 6). The level of acceleration at the base level is about 0.52 to 0.77 time of the acceleration at the table level in isolated conditions (dry and wet).

The bases used on the shake table, to provide the interface layer on the bottom side of the model has base acceleration equal to the base acceleration of the table as they were affixed with the shake table. And it was observed from the Table 1 that the geotextile does effectively reduce acceleration of the model.

The other important observation is that the peak interstorey drift, it is to be noted here that, the fixed base interstorey drift is comparatively more than that of the base isolated in dry state and wet state of isolation. Fig.7 clearly illustrates that isolated case has clearly reduced the storey displacement.

The other important aspect which is known from Table 1 is the peak base displacement, which is less than 15 percent of the maximum shake table designed displacement (50 mm), and the permanent displacement is also found to be about 1-2% of the maximum designed shake table displacement.

Finally, we note that that during the entire testing program no uplift occurred at the base of the interfaces and no torsional response was observed.

4. CONCLUSIONS

Shake table tests have been performed to evaluate the behavior of the friction base isolating system installed in a three dimensional 2-storey RC Framed structure. The results show that:

1. The system is effective in protecting the structural system from extreme seismic loading conditions with significantly different frequency content and all tests the model remained elastic.
2. No bearing uplift occurred despite the testing at higher frequencies giving table acceleration greater than 1g.
3. The maximum recorded peak base displacement is very small compared to the peak table displacement, while the maximum permanent displacement is also under 2 percent of the maximum peak table displacement.
4. The observed results obtained in dry and wet conditions shows, that the observed response of the structure does not differ much in wet state which have relatively lower friction coefficient. Thus, not much effected by moisture.

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